L6: Entry 3 of 10 File: USPT Oct 5, 1999

DOCUMENT-IDENTIFIER: US 5961559 A
TITLE: Automatic guided vehicle and automatic guided vehicle control method

Detailed Description Text (24):
When the travel instruction code indicates an instruction other than a halt command, a determination is made at step S105 as to whether or not the travel instruction code indicates a travel speed. After storing the travel instruction speed in RAM 21 as an up-date travel instruction speed at step S106 when the answer is affirmative, or directly when the travel instruction code provides instructions other than travel instruction speeds, the flowchart logic proceeds to step S107 where a center position value is detected as a lateral deviation of the automatic guided vehicle 3 from the path guide tape 2A at step S107. Travel control speeds for the drive wheels 8 and 9 are calculated based on the lateral deviation and the up-dated travel speed at step S108. After reading the rotational speed calculated at step S108 as a travel control speed VSL of the left drive wheel at step S109 and reading the actual traveling speed VL of the left drive wheel at S110 subsequently, the speed difference of the actual traveling speed from the travel control speed VSL for the left drive wheel VDL is calculated at step S111. Subsequently to a deceleration control judgement at step S112, a determination is made at step S113 as to whether deceleration is necessary, in other word, whether or not the speed difference of the left drive wheel VDL is greater than zero. When the speed difference VDL is equal to or less than zero, an acceleration rate is calculated at step S124. Subsequently, the contact switches Ra-Rd are operated based on the acceleration rate by the pulse width modulation control (PWM) at step S125 to drive the drive motor 6 in the normal direction at step S126. On the other hand, when the speed difference VDL is greater than zero, subsequently to a brake changeover judgement based on the critical speed CL at step S114, a determination is made at step S115 as to whether or not both regenerative braking and reverse braking are demanded to apply. This determination is made by comparing the speed difference VDL with the critical speed CL. When the speed difference VDL is greater than the critical speed CL, then, a regenerative braking rate is calculated at step S121. Subsequently, the contact switches Ra-Rd are operated based on the regenerative braking rate by the pulse width modulation control (PWM) at step S122 to drive the drive motor 6 so as to produce desired generated energy. On the other hand, when the speed difference VDL is equal to or less than the critical speed CL, then, subsequently to brake changeover judgement according to the critical difference BL at step S116, a determination is made at step S117 as to whether the reverse braking is demanded. When the speed difference VDL is equal to or greater than the critical difference BL, a reverse braking rate is calculated at step S11 8. Subsequently, the contact switches Ra-Rd are operated based on the reverse braking rate by the pulse width modulation control (PWM) at step S119 to drive the drive motor 6 in the reverse direction. For the right drive motor 7, the same operation is performed through steps S130-S147.

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L21: Entry 7 of 18 File: USPT Nov 24, 1981

DOCUMENT-IDENTIFIER: US 4302811 A
**** See image for Certificate of Correction ****
TITLE: Automatic train operation with position stop and velocity control

Abstract Text (1):
An improved automatic control system for a train of transit vehicles which regulates the velocity of the train and its braking rate in accordance with a predetermined velocity/distance profile. The system includes apparatus for compensating for variations in wheel diameter and train length in such a manner as to assure that the center of the train regularly stops at a predetermined point with respect to a desired station stopping point. On board receivers are responsive to wayside signal devices for establishing the operating velocity of the vehicle and for initiating entry into the predetermined braking profile. Since vehicle control is effected by wayside signal devices, the distance between stopping points may be indefinite. The system includes apparatus which permits passing selected stopping points when desired.

Brief Summary Text (2):
This invention relates to automatic control systems for traction vehicles and has particular application to rapid transit or other railway vehicles.

Brief Summary Text (3):
Automatic train operation (ATO) control systems have been developed to improve the operation of rapid transit systems and to minimize the opportunity for accidents caused by human error. In general, ATO systems include signal devices positioned along a fixed guideway, such as a railway track or monorail system, for providing information to vehicles on the guideway as to the position of the vehicles and the velocity at which the vehicles are to proceed. Communication receivers on the vehicles receive the information from the wayside signal devices and convey it to the ATO control circuitry which controls power and braking to regulate the velocity of the vehicles.

Brief Summary Text (5):
Although ATO systems for controlling the velocity of a vehicle are not unusually complex, the addition of control circuitry to stop the vehicle at a predetermined position without excessive deceleration or jerk can result in a quite complex arrangement. Furthermore, the implementation of position stop circuitry using analog techniques--which require multiple potentiometers for setting voltage levels and rely on capacitor energy storage--may become, in addition to being complex, excessive in physical size. For example, many additional components may be needed if the position stop circuit is required to adjust the stopping point of the lead vehicle in a train of vehicles which can vary from one to ten vehicles in length. In addition, the diameter of the steel wheels on the vehicles change with service and the system must compensate for that change in computing the position of the train with respect to the stopping point.

Brief Summary Text (7):
It is an object of this invention to provide an improved ATO control system for a vehicle traveling on a fixed guideway.

Brief Summary Text (8):
It is another object of this invention to provide an improved ATO control system with a position stop control which can be easily adjusted to accommodate variable train

lengths and wheel diameters.

Drawing Description Text (3):
FIG. 1 is a representative diagram of a pair of vehicles on a fixed guideway which are controlled in accordance with the present invention to decelerate smoothly to a full stop at a desired stopping point;

Drawing Description Text (8):
FIG. 6, which comprises the three sheets labeled 6A, 6B, and 6C is a schematic representation of the braking rate regulating portion of FIG. 2; and

Drawing Description Text (9):
FIG. 7 is an illustration of the performance characteristics of a vehicle incorporating the present invention.

Detailed Description Text (2):
Referring to FIG. 1, there is illustrated a train of two vehicles 10 and 12 which are adapted to move along a rail or fixed guideway 14 from a starting point 16 to a station or terminal 18 at which is located a desired stopping point 20. Positioned along the guideway 14 are a plurality of wayside signal devices indicated schematically at 22, 24, and 26, which devices may be of a passive or active type, both types being well known in the art. Preferably the lead vehicle 12 in the train is designated as the controlling vehicle and is accordingly shown as including a receiver, indicated schematically at 28, for receiving information from the wayside signal devices 22, 24 and 26. In practice, the device 22 may provide information specifying a desired velocity for the vehicles 10 and 12 whereas the devices 24 and 26 may provide information specifying the distances D.sub.1 and D.sub.2, respectively, to the desired stopping point 20. Over a relatively long section of track, the device 22 may be repeated any number of times and may command the same or different velocities. Similarly, the ATO system on board the vehicle 12 may be capable of responding to the device 24 for stopping the train at the desired stopping point 20, but additional signal devices such as device 26 may be added to the wayside system in order to provide additional assurance of the accuracy of the ATO system by periodic updates.

Detailed Description Text (3):
Although not shown in detail, the vehicles 10 and 12 are preferably of the type powdered by electric traction motors connected to selected wheels of each vehicle.

Detailed Description Text (4):
Referring now to FIG. 2, there is illustrated a preferred embodiment of an ATO control system according to the present invention for providing a tractive effort control signal which will control the power supplied to the electric traction motors of a vehicle indicated at 12. The system includes a speed sensor 32 associated with a wheel (not shown) of the vehicle 12 for developing an output signal representative of the angular velocity of the wheel. The speed sensor 32 may comprise any of the well known types of velocity sensing devices and is preferably a tachometer generator mounted to produce a plurality of discrete pulses for each revolution of the monitored wheel, such as by being mounted adjacent a driven gear so that a pulse is produced each time a gear tooth passes by the sensor 32.

Detailed Description Text (5):
Included also is a switch 34 which may be manually set to indicate the number of vehicles in the train. Another switch 36, which may also be manually set, is included to indicate the diameter of the wheel being monitored by sensor 32 since the wheel diameter affects the number of revolutions the wheel will turn in moving through a fixed linear distance. Both switches 34 and 36 are arranged to provide an output signal indicative of their respective set positions.

Detailed Description Text (7):
Frequency to voltage converter 40 may be of a type well known in the art for converting a string of pulses at varying frequencies to a d-c voltage level representative of the pulse frequency. The voltage magnitude from converter 40 is representative of the linear velocity of the vehicle 12. Accordingly, the converter 40 is responsive to the signal from switch 36 for adjusting the magnitude of its velocity representative output voltage as a function of the diameter of the wheel being

monitored by sensor 32. Such an adjustment is necessary since the number of pulses per wheel revolution produced by sensor 32 remains constant even though the wheel diameter may vary resulting in a varying number of pulses per unit of linear distance traveled by the vehicle 12. For adjustment purposes the converter 40 may include an output amplifier whose gain is adjusted by the signal from switch 36 such that the analog velocity signal from converter 40 is maintained proportional to linear velocity of the vehicle 12.

Detailed Description Text (8):
The program stop function is implemented when the vehicle 12 passes a wayside signal device and an appropriate signal is detected by a vehicle carried program stop marker receiver 42. The details of such a receiver 42 are well known in the art and may take the form of the carrier receivers shown and described in the aforementioned U.S. Pat. No. 3,334,224. As disclosed in that patent, the receiver 42 is preferably a tone modulated receiver which identifies the location of the received signal by its frequency modulation. Since each wayside signal device is located at a different predetermined fixed distance from a desired stopping point, the information conveyed by each device is an identity code rather than distance data.

Detailed Description Text (9):
The program stop marker receiver 42 provides an output signal representing the identity of the received wayside signal to a program stop control logic circuit 44. The logic circuit 44 provides several functions, a primary function being to convert the signal from receiver 42 to a digital address for use in addressing the memory device 38. The combination of the digital signals from logic circuit 44, switch 34 and switch 36 provides a complete digital address specifying a location in memory device 38 at which is stored a digital number representative of the number of revolutions through which a wheel of the diameter specified by switch 36 will revolve in order to stop the center of the train of vehicles at the desired stopping point. When the memory device 38 is addressed, it transfers to its output terminals the value stored at the addressed location. The functions performed by logic circuit 44 are initiated by closing a START switch 45.

Detailed Description Text (10):
A counter 46 of a type well known in the art has its input terminals connected to the output terminals of memory device 38. Each time that a wayside signal device is detected by the vehicle 12 and a new address generated by logic circuit 44, the circuit 44 also provides an enable signal to counter 46 so that the digital number developed at the output terminals of memory device 38 is transferred into an internal register of counter 46. The value in the internal register is thereafter counted down as a function of the revolutions of the wheel whose velocity is being monitored. As shown, the counting down function is accomplished by connecting the pulses developed by speed sensor 32 to a clock terminal of counter 46 via a conductor 30. Thus, the sensor 32 produces pulses representative of wheel rotation which pulses are effective to decrement the number stored in counter 46. Preferably the pulses developed by sensor 32 are shaped by a pulse shaper circuit 48 before being supplied to counter 46. Such shaping circuits are well known in the art and may also include level detection to minimize spurious pulses caused by a noisy environment.

Detailed Description Text (11):
Since the number stored in the counter 46 is decremented as a function of the revolutions of the vehicle wheel, i.e., the distance actually traveled by the vehicle, the number remaining in the counter 46 at any time is a reference signal representative of the distance remaining to the desired stopping point. In a preferred embodiment the power control system for the vehicle 12 requires analog command or error signals for operation. Accordingly, the digital reference signal from counter 46 is converted to an analog signal by a digital-to-analog (D/A) converter 50 of a type well known in the art. The magnitude of the signal developed by D/A converter 50 then becomes a distance-to-go reference signal `d.`

Detailed Description Text (12):
In the program stop mode of operation the control system is arranged to control the vehicle deceleration rate such that a predetermined velocity versus distance profile is maintained. The criteria for the profile is to provide smooth, jerk free deceleration with complete cessation of movement at the desired stopping point. The

program stop control system therefore supplies to the vehicle power control system a control error signal or command signal which calls for a desired braking rate of deceleration rate. The desired deceleration rate may be set at any selected value, e.g., one mile per hour per second or five miles per hour per second or any other desired value, and that rate could then be commanded by an appropriate magnitude of the control error signal. However, stopping the vehicle at the desired point requires dynamic adjustment of the control error signal as a function of the position of the vehicle on the guideway. The system thus far described provides a critical component of the dynamic adjustment arrangement, i.e., the reference distance-to-go signal `d` is a continuous reference of the actual position of the vehicle on the guideway with respect to the desired stopping point. Another critical component in the dynamic adjustment arrangement is the determination of whether the velocity of the vehicle at any actual position meets the predetermined velocity/distance profile. To this end, another portion of the program stop circuit continuously determines the distance required to stop the vehicle given its current velocity and the desired deceleration rate.

Detailed Description Text (13):
In order to determine distance as a function of velocity, the velocity representative pulses developed at an output terminal of pulse shaper 48 are applied to a first input terminal of a multiplier circuit 52. A second input terminal of multiplier circuit 52 is connected to an output terminal of frequency-to-voltage converter 40 for receiving a signal whose magnitude is representative of vehicle velocity. Multiplier circuit 52 operates to multiply the signals on its first and second input terminal to thereby develop at an output terminal a signal representative of the product of the two input signals. Since both input signals are representative of the velocity of the vehicle 12, the product signal developed by circuit 52 is representative of the square of vehicle velocity.

Detailed Description Text (17):
From junction 58 the brake control error signal is coupled through a switch 60, an amplifier circuit 62 and an analog "OR" circuit 64 to an output conductor 66 and thence to the power control system for the motors propelling the vehicle 12. The signal on conductor 66 whether provided by the brake rate circuitry just described or by the velocity control circuit to be described hereinafter is a tractive effort control signal for the power controlling system of the vehicle 12. A detailed description of the use of the signal on conductor 66 for controlling the vehicle 12 may be had by reference to U.S. Pat. No. 3,457,487 issued on July 22, 1969 to D. Cooper and assigned to the General Electric Company. In that patent the block labeled "TRACTIVE EFFORT SIGNAL SOURCE" corresponds to the system diagram herein identified as FIG. 2.

Detailed Description Text (18):
Referring still to FIG. 2, the desired deceleration rate `a` may be selected by a rate selection circuit indicated schematically as a switch 68 on board the vehicle 12. The specifying of a desired rate could also be implemented with a wayside signal device and on-board receiver. The switch 68 is preferably arranged such that a different predetermined voltage magnitude is produced for each different desired braking or deceleration rate.

Detailed Description Text (19):
For most of the operating velocities of the vehicle the signal developed by switch 68 is used as the desired deceleration rate signal. However, at very slow or relatively fast speeds, the signal from switch 68 is modified slightly to avoid "jerks" or step-changes in velocity. This signal modification is accomplished by coupling the signal from switch 68 to a first input terminal of a summing junction 70. A second input terminal of junction 70 is connected to an output terminal of a function generator circuit 72. The circuit 72 has an input terminal connected to the output terminal of converter 40 for receiving the signal representative of the velocity of the vehicle 12.

Detailed Description Text (20):
The function generator circuit 72 may be of any of the types well known in the art for providing an output signal as a predetermined function of an input signal. In the preferred embodiment the circuit 72 is arranged to provide an output signal in

response to either very small or very large amplitude input signals. The arrangement is such that for vehicle velocities between, for example, 3 and 50 miles per hour, the circuit 72 has no effect on the output signal from summing junction 70. For velocities less than 3 miles per hour the circuit 72 clamps the deceleration rate signal `a` to a predetermined small value. For velocities greater than 50 miles per hour, the circuit 72 clamps the rate signal `a` to a predetermined relatively large value. A more detailed discussion of this function is discussed hereinafter with regard to FIG. 6.

Detailed Description Text (21):
The control system of FIG. 2 also provides for velocity control of the vehicle 12 in response to velocity command signals from wayside signal devices. Thus, the system includes a velocity command receiver 74 preferably of the type described in the aforementioned U.S. Pat. No. 3,334,224. The signals received by receiver 74 are coupled to a velocity reference generator 76 which decodes the received signals and provides a direct current velocity reference output signal whose voltage amplitude is representative of the commanded velocity. Reference generator 76 may also be of the type described in U.S. Pat. No. 3,334,224. The velocity reference signal is coupled to a summing junction 78 where it is algebraically summed with the velocity feedback signal from converter 40 to generate a velocity error signal.

Detailed Description Text (22):
In the embodiment of FIG. 2 the velocity error signal is modified by an additional compensation signal coupled to a third input terminal of summing junction 78 from a function generator 80. The compensation signal provides a bias voltage which is summed with the velocity reference signal to produce a larger magnitude velocity error signal as vehicle velocity increases. The larger magnitude velocity error signal is used to compensate for increases in wind drag with increasing velocity. Since the compensation signal is necessarily a function of velocity, the velocity feedback signal from converter 40 is coupled to an input terminal of function generator 80 and provides a reference for developing the compensation signal. The compensation signal may be a linear or non-linear function of the velocity feedback signal depending upon the dynamics of the vehicle 12 and the capability of the motors and power system driving the vehicle. Function generators suitable for such applications are well known in the art and will not be detailed herein.

Detailed Description Text (23):
The velocity error signal is coupled from summing junction 78 through an amplifier 82 to a second input terminal of analog "OR" circuit 64. OR circuit 64, which may be a diode OR circuit, is arranged such that the most restrictive of either the velocity error signal or the brake control error signal is coupled through onto conductor 66 to thereby become the tractive effort signal controlling the application of power to the motors of vehicle 12.

Detailed Description Text (24):
An additional feature incorporated into the present inventive tractive effort control system includes a brake anticipation circuit 84 which anticipates the entrance of the vehicle into a braking mode and is adapted to reduce the vehicle tractive effort signal on conductor 66 in order to smooth the transition from a propulsion mode into the position stop mode. The brake anticipation circuit 84 is enabled by a signal from logic circuit 44 via conductor 86. The distance-to-go error signal at the output terminal of summing junction 56 is coupled via conductor 88 to a second input terminal of anticipation circuit 84. If the distance-to-go error signal is less than a predetermined positive value (as indicated by a small signal on the conductor 88) and the train is moving at a relatively high speed (as indicated by a large linear velocity signal), the brake anticipation circuit 84 generates an output signal of a predetermined magnitude which is applied to a third input terminal of analog OR circuit 64. The signal from anticipation circuit 84 clamps the tractive effort signal to the predetermined magnitude thereby calling for a braking rate which permits a smoother transition onto the program stop profile if the train is moving too fast when the receiver 42 on the lead vehicle passes the first or outermost one of the cooperating wayside signal devices 24 and 26 as the desired stopping point is approached. In an exemplary embodiment, a braking rate of 0.7 miles per hour per second was selected to provide a smooth transition. The output signal of the brake anticipation circuit 84 becomes ineffective once the vehicle 12 begins to approximate the predetermined velocity/distance profile. This feature will be explained more fully

hereinafter in conjunction with the description of FIGS. 6 and 7.

Detailed Description Text (25):
The normally open switch 60, illustrated as a relay contact but which may be a solid state switch such as a junction field effect transistor, is closed by a signal from logic circuit 44 generated in response to entry into the program stop mode of operation. In the event that it is not desired to stop the vehicle 12 at the approaching station, there is provided a manually operable bypass switch 90 which, when closed, forces the logic circuit 44 to de-energize switch 60 so that the vehicle 12 operates in response to only the velocity error signal. Closing of the bypass switch 90, however, does not affect the operation of the distance-to-go circuitry and accordingly, the distance-to-go error at the output of summing junction 56 continues to be updated. This permits the vehicle 12, within reasonable limits, to be forced back onto the programmed velocity/distance profile in the event that it is subsequently decided to stop at the approaching station and the bypass switch 90 is released.

Detailed Description Text (26):
Referring now to FIG. 3, which is divided into three sheets labeled FIGS. 3A, 3B, and 3C, there is shown a more detailed arrangement of the digitally implemented program stop control circuit of FIG. 2. For purposes of explanation the ATO system will be assumed to have two check points prior to reaching a predetermined stopping point or station, each check point having a wayside signal device for generating a position signal receivable by the passing vehicle. The program stop marker receiver 42 operates in the manner described in the aforementioned U.S. Pat. No. 3,334,224 to provide a first signal indicated as PS1 on a first conductor 100 when the outermost distant signal device is passed and a second signal indicated as PS2 on a second conductor 102 when the next distant signal device is passed. Preferably the PS1 and PS2 signals are generated by closure of relay contacts in the manner described in U.S. Pat. No. 3,334,224. Preferably also, the relay logic is so arranged that a system reset signal can be applied to force all relays to their initialized condition. Since the signals PS1 and PS2 are generated by actuation of relay contacts, both signals are coupled through a contact bounce eliminator 104 of a type well known in the art. The contact bounce eliminator 104 may be, for example, a type MC 14490 as shown and described on pages 8-30 et seq. of Volume 5, Series A of The Semiconductor Data Library, McMOS Integrated Circuits, published in 1975 by Motorola Semiconductor Products, Inc. Another stage of the eliminator 104 is also used to shape the station bypass signal BPR produced when the switch 90 is closed.

Detailed Description Text (31):
The balance of the input address code for PROM's 124 and 126 is provided by the train length switch 34 and the combination of the PS1 and PS2 signals from the program stop marker receiver 42. The PS1 signal is coupled via conductor 127 through an amplifier 128 to the A.sub.5 input terminals of PROM's 124 and 126. Similarly, the PS2 signal is coupled via conductor 129 through an amplifier 130 to the A.sub.6 input terminals of PROM's 124 and 126.

Detailed Description Text (32):
The illustrative system is adapted to be utilized with a train of vehicles not exceeding eight cars in length. However, it will be obvious that the system is readily adaptable to accommodate larger numbers of vehicles. It is also apparent that stopping a train of vehicles so that the center of the train is at the mid-point of a station will result in a vehicle being centered on the mid-point of the station in the case of a train having an odd number of vehicles whereas a train having an even number of vehicles would stop with the junction between two vehicles being centered on the station mid-point. Accordingly, it is preferable to adjust the train center point for stopping purposes as a function of an odd number of vehicles. For example, the lead vehicle in a train of one vehicle or two vehicles will stop with its center at the station mid-point. Similarly, the second vehicle in a train of three vehicles or four vehicles will stop with its center at the station mid-point.

Detailed Description Text (33):
In order to stop the train in the manner described, the train length selector switch 34 is set to the position indicative of the number of vehicles in the train. In the one or two vehicle position, the switch 34 energizes a relay coil 131 via a conductor

132 causing relay contact 133 to be picked up and couple a voltage V+ onto a conductor 134. In the three or four vehicle position, the switch 34 energizes a relay coil 135 via a conductor 136 causing relay contact 137 to be picked up and couple the voltage V+ onto a conductor 138. In the five or six vehicle position, the switch 34 energizes both relay coils 131 and 135 thereby coupling the voltage V+ onto both conductors 134 and 138. In the seven or eight vehicle position, neither relay coil 131 nor 135 is energized and both conductors 134 and 138 are grounded. As shown, both relay coils 131 and 135 are shunted by respective voltage spike suppression circuits 139 and 140. Adaptation of a multi-position switch such as switch 34 to produce the described logic function is well known to those having ordinary skill in the art.

Detailed Description Text (38):
If the station stop is bypassed, i.e., if switch 90 is closed so that the system is maintained in a velocity control mode rather than a program stop control mode, the counters 144, 146 and 148 will continue to count down even though the output signals are not used for stopping the vehicle 12. In a preferred implementation the system generates a stop signal prior to the counter reaching zero counts. In order to reset the program stop system when a station stop is bypassed, a logic circuit is provided for monitoring the count in the counters 144, 146 and 148 and for generating a SYSTEM RESET signal when the count reaches a predetermined value. The logic system comprises a plurality of diodes 159 connected to selected output terminals of counters 146 and 148 in a logical OR gate arrangement so as to produce a logical zero output signal whenever the count remaining in the counter 46 is equivalent to a decimal count of 31. In the OR gate arrangement the cathodes of the diodes 159 are each connected through a resistor 161 to a base terminal of an NPN transistor 163. The emitter terminal of transistor 163 is connected to ground potential whereas its collector terminal is connected to a relatively positive voltage V+ through a resistor 165. A base bias resistor 167 is also connected between the base terminal of transistor 163 and ground potential. When a logical zero signal is developed at the base terminal of transistor 163, the transistor 163 is rendered non-conducting and the positive voltage V+ connected to the resistor 165 appears at the collector terminal of transistor 163. The positive voltage signal at the collector terminal of transistor 163 is used as the SYSTEM RESET signal.

Detailed Description Text (39):
When the vehicle 12 is permitted to stop at a station, the tach pulses are no longer generated and the counter 46 ceases counting down. When the vehicle operator closes the START switch 45, one set of contacts of the switch 45 are connected to apply a logical zero or ground potential to the base terminal of transistor 163. Accordingly, when the vehicle 12 is commanded to depart from a station, a SYSTEM RESET signal is developed at the collector terminal of transistor 163.

Detailed Description Text (41):
The PS1 and PS2 signals from contact bounce eliminator 104 (shown in FIG. 3) are coupled into a plurality of parallel connected circuits. As explained previously, the PS1 signal is generated when the vehicle passes the outermost program stop signal device. The PS1 signal thereafter stays at a high or logical 1 level until a system reset occurs. The PS2 signal is generated when the vehicle passes the second program stop signal device and it also thereafter stays at a high or logical 1 signal level until a SYSTEM RESET signal is produced. The PS1 and PS2 signals are applied in parallel to first and second input terminals of an AND gate 174, to first and second input terminals of an AND gate 176, to first and second input terminals of an exclusive OR circuit 178, to first and second input terminals of an OR circuit 180, and to respective input terminals of inverting amplifiers 182 and 184. In addition the PS2 signal is applied to an input terminal of an inverting amplifier 186 to develop on a conductor 188 a signal corresponding to PS2, i.e., a signal which is a logical inversion of PS2. The PS2 signal is not used in the preset enable or reset circuitry but is developed here for application in that part of the program stop control logic circuit 44 shown in FIG. 6.

Detailed Description Text (42):
Turning first to the inverting amplifiers 182 and 184, the output terminal of inverting amplifier 182 is connected to a first input terminal of an AND gate 185. The output terminal of inverting amplifier 184 is connected to a second input terminal of the AND gate 185. By definition an AND gate provides a logical 1 output signal only

when all of its input terminals are supplied with a logical 1 input signal. Accordingly, when the vehicle has not entered into the program stop mode of operation so that both PS1 and PS2 signals are at a logical 0 level, the inverters 182 and 184 provide logical 1 input signals to both of the input terminals of AND gate 185. The output signal developed at an output terminal of AND gate 185 is therefore at a logical 1 level. The output terminal of AND gate 185 is coupled via a conductor 187 to an amplifier 190 which provides the RESET signal on a conductor 192. The output terminal of AND gate 185 is also coupled to the set input terminal of a flip flop 194. A reset terminal of flip flop 194 is connected to an output terminal of OR gate 180, which gate 180 develops on a conductor 224 a signal corresponding to PS1+PS2, i.e., a signal which is a logical 1 whenever PS1 or PS2 or both are at logical 1 levels. As will be apparent, prior to entering the program stop mode of operation, the output signal developed by OR gate 180 will be a logical 0 and since the signal developed by AND gate 185 is a logical 1, the flip flop 194 will be in a set mode. In the set mode of operation the Q output terminal of flip flop 194 will be at a logical 1 level and the Q output terminal will be at a logical 0 level.

Detailed Description Text (43):
The Q output terminal of flip flop 194 is connected to an input terminal of AND gate 196. An output terminal of AND gate 196 is connected to an input terminal of AND gate 168. Accordingly, when flip flop 194 is in a set mode, a logical 0 applied to an input terminal of AND gate 196 from the Q output terminal of flip flop 194 will cause the output signal developed by AND gate 196 to be a logical 0 which in turn being applied to AND gate 168 will provide a logical 0 output signal from this latter AND gate. Since AND gate 168 is connected to control the application of the CLOCK signals being developed on line 172, the presence of a logical 0 on one of its input terminals will result in inhibiting the CLOCK signals. Thus, whenever the vehicle has not entered into the program stop mode of operation, CLOCK signals are inhibited.

Detailed Description Text (53):
Referring now to FIG. 6, which comprises the three sheets labeled FIG. 6A, FIG. 6B, and FIG. 6C, there is shown a more detailed illustration of the circuitry for developing the tractive effort control signal from the distance-to-go reference signal and the distance-to-go feedback signal based upon the desired acceleration rate signal. As indicated previously, the distance-to-go feedback signal is computed as the quotient of the square of actual velocity of the vehicle divided by twice the desired acceleration rate. In FIG. 1 this was illustrated as being accomplished by a multiplier circuit which multiplies a signal representative of the frequency of the pulses generated by the speed sensor by a second signal which is an analog signal whose amplitude is proportional to the frequency of the speed sensor output signals. As shown in FIG. 6, the analog VELOCITY signal developed by the frequency to voltage converter 40 is applied via a conductor 252 through a variable resistor 254 and a fixed resistor 256 to a source terminal of a field effect transistor 258. The field effect transistor 258 is utilized as a switch which is turned off and on by the shaped speed sensor pulses developed by pulse shaper 48. These shaped speed sensor pulses or TACH pulses are applied via conductor 260 to a gate terminal of the field effect transistor 258. A bleeder resistor 262 is connected between the conductor 260 and ground. Inverse parallel connected diodes 264 and 266 are connected from the source terminal of FET 258 to ground to limit the voltage magnitude applied to the source terminal.

Detailed Description Text (55):
The effect of switching transistor 258 by application of the speed sensor pulses is to produce an output signal which is a function of the amplitude of the velocity proportional signal produced at the source terminal of the transistor and a function of the pulse width of the signals applied to the gate terminal of the transistor. Thus, a signal is developed at the drain terminal of transistor 258 which is essentially a pulse width, pulse height product and is therefore proportional to the square of the velocity of the vehicle. The gain of the amplifier 268 is adjusted such that the signal produced at its output terminal is proportional to the square of the velocity, i.e., V.sup.2, divided by twice the desired acceleration rate \`a.\` The value of the acceleration rate \`a\` is controlled by the scaling of the gain of the amplifier 268.

Detailed Description Text (60):

The drain terminal of FET 294 is connected to an inverting input terminal of an amplifier 306 which is connected in an operational amplifier mode. The feedback loop for the operational amplifier is provided by a resistor 308 and a capacitor 310 which are connected from a cathode terminal of a diode 316 to the inverting input terminal of amplifier 306. The diode 316 has its anode connected to an emitter terminal of a transistor 312 whose base terminal is connected to an output terminal of amplifier 306. The collector terminal of transistor 312 is connected to voltage source V+. The inclusion of the transistor 312 in the feedback loop provides extra current on the output line 66 to drive the control equipment powering the vehicle traction motors. The diode 316 forms part of the analog OR circuit illustrated at 64 in FIG. 2. The signal developed on the line 66 is the tractive effort control signal for the system when in the program stop mode of operation.

Detailed Description Text (64):
Another field effect transistor (FET) 334 also has its drain terminal connected to the drain terminal of FET 294 so that a lower value of deceleration as desired for the cushion stop mode may be called for just prior to actual stopping of the vehicle. The source terminal of FET 334 is connected through a resistor 336 to a source of negative voltage V-. The voltage level applied to the source terminal of FET 334 is limited by the inverse parallel connected diodes 338 and 340. Both the FET 322 and 334 are controlled by signals indicating whether the vehicle is moving, whether a PS1 or PS2 mode has been selected and the speed of the vehicle. The ohmic resistance of the series resistor 336 is made much larger than that of resistor 320 in order to call for a smaller brake rate during cushion stop. The FET 334 is effective to control the braking rate only within a very narrow low speed range as will become apparent. By changing the value of the resistor 320 and the gain of the amplifier 268, the system can be adjusted to any desired deceleration rate. Alternatively, additional "stages" of deceleration could be implemented by adding FET networks as desired.

Detailed Description Text (65):
The analog velocity signal generated by the frequency-to-volts converter 40 is applied to a detector circuit 342 which provides an output signal indicative of whether the vehicle is moving or not moving. The circuit 342 may be a simple voltage level detector with a logic output such that a no-motion signal (NM) is produced on a conductor 344 if the velocity of the vehicle is determined to be less than a predetermined threshold level, e.g., two miles per hour. If the velocity of the vehicle is greater than the predetermined threshold level an NM or motion signal is produced on a conductor 346.

Detailed Description Text (66):
The velocity signal is also coupled into another motion detection circuit 348 which determines if the velocity of the vehicle is greater than a second predetermined threshold, which in the present illustrative system may be, for example, 5 miles per hour. In addition, the velocity signal is also coupled into a third threshold detector 350 which detector is set to determine whether the speed of the vehicle exceeds a third threshold level, which in this example has been set at 57 miles per hour. The second threshold detector 348 produces an output signal identified as a low motion signal, or LM signal, which is a logical 1 if the velocity of the vehicle is in excess of 5 miles per hour. The third threshold detector 350 produces a high motion, or HM signal, which is a logical 1 if the velocity of the vehicle exceeds the 57 miles per hour threshold. The threshold detector 342 may comprise a pair of circuits similar to those shown in the threshold detector 348 and 350. As shown, the threshold detectors 348 and 350 may each comprise voltage comparators with appropriate biasing networks selected to cause the comparators to switch output states when the input signal reaches an amplitude corresponding to the respective predetermined threshold levels. As such threshold level detectors are well known in the art, a detailed description of their construction will not be given.

Detailed Description Text (67):
The NM signal is connected to a first input terminal of an AND gate 352, a second input terminal of AND gate 352 being connected to receive the LM signal from the comparator 348. An output terminal of AND gate 352 is connected to a first input terminal of an OR gate 354. The second input terminal of OR gate 354 is connected to an output terminal of an AND gate 356. This latter AND gate has a first input terminal connected to receive the NM signal and a second input terminal connected to receive

the LM signal. The LM signal is developed at an output terminal of an inverter 358 whose input terminal is connected to receive the LM signal. With this arrangement the logical AND gate 356 provides a logical 1 output signal whenever the velocity of the vehicle is less than the first threshold level established by the NM signal, i.e., 2 miles per hour in the present illustration. The AND gate 352 on the other hand provides a logical 1 output signal only when the NM signal and the LM signal are at logical 1 levels. Thus, AND gate 352 will produce a logical 1 level signal when the vehicle speed is greater than the first threshold level and also greater than the second threshold level established by the comparator circuit 348. The net result is to provide a logical 1 output signal to the OR gate 354 if the vehicle speed is less than the first threshold level, e.g., 2 miles per hour, or if the speed is greater than the second threshold level, e.g., 5 miles per hour. The purpose, of course, is to provide a narrow range, i.e., a speed between 2 and 5 miles per hour when a cushion stop will be implemented.

Detailed Description Text (68):
An output terminal of OR gate 354 is connected to a first input terminal of AND gate 360. A second input terminal of AND gate 360 is connected to an output terminal of AND gate 300. It will be recalled that the output signal generated by the AND gate 300 was a logical 1 whenever the system was in a position stop control mode. Accordingly, when in the position stop control mode the AND gate 360 will develop a logical 1 outut signal whenever the velocity of the vehicle is less than the first threshold level of 2 miles per hour or greater than the second threshold level of 5 miles per hour. An output terminal of AND gate 360 is connected to an input terminal of an inverter 362. The inverter serves to convert the logical 1 signal developed by AND gate 360 into a logical 0 signal which is applied to a gate terminal of the FET 322. The FET 322 is gated into conduction by the logical 0 signal.

Detailed Description Text (69):
During the time when the vehicle velocity is between the first and second threshold levels the FET 322 is non-conductive and a gate signal must be applied to the FET 334 in order to render it conductive. To this end, the NM signal is coupled from the conductor 346 to a first input terminal of an AND gate 364. A second input terminal of AND gate 364 is connected to an output terminal of the inverter 358. Because an AND gate produces a logical 1 signal only when both of its input terminals are at a logical 1 level, the AND gate 364 will produce a logical 1 signal only if the vehicle is in motion so that the NM signal is a logical 1 and if the vehicle speed is less than 5 miles per hour so that the LM signal is a logical 1. The output terminal of AND gate 364 is connected to a first input terminal of AND gate 366. A second input terminal of AND gate 366 is connected to the output terminal of AND gate 300 so that the AND gate 366 will only be active when the system is in a programmed stop control mode. An output terminal of AND gate 366 is connected to an inverter 368 which inverts the logical 1 signal developed by the AND gate 366 and couples it to the gate terminal of the FET 334. The arrangement thus described provides a deceleration rate reference which is at a first level when the velocity of the vehicle is less than 2 miles per hour or greater than 5 miles per hour and provides a second deceleration rate when the velocity of the vehicle is between 2 and 5 miles per hour.

Detailed Description Text (70):
As was described with reference to FIG. 2, the inventive control system includes a brake anticipation circuit which anticipates the entry of the vehicle onto the desired speed/distance profile during the position stop control mode and operates to smooth the transistion from a motoring into a braking mode. The brake anticipation circuit 84 of FIG. 2 is shown in FIG. 6 and includes the threshold detector 350 which detects when the velocity of the vehicle is exceeding a third threshold level. An output terminal of the threshold detector 350 is connected to a first input terminal of a logical AND gate 372. To make the AND gate active only when the system is in a PS1 program stop control mode, a second input terminal of the AND gate 372 is coupled to an output terminal of a logical AND gate 370. The logical AND gate 370 has first and second input terminals which are connected respectively to receive the PS1 and PS2 signals described previously with respect to FIG. 4. The logical signal developed by the AND gate 370 will be a logical 1 if, and only if, the system is in a position stop mode such that the PS1 signal has been generated and the second signal device has not yet been detected. In the event the second signal device has been detected, it is desirable to inhibit the brake anticipation system and to assure that maximum braking

is effected. The AND gate 372 has its output terminal connected to a first input terminal of an AND gate 374, a second input terminal of AND gate 374 being connected to the output terminal of AND gate 300. The AND gate 374 is active only when the system is in a program stop control mode as evidenced by a logical 1 signal being generated by the AND gate 300. Thus, a logical 1 output signal will be generated by the AND gate 374 if the system is in a program stop control mode and a second signal device has not been detected and the vehicle speed is greater than a third threshold level.

Detailed Description Text (71):
An output terminal of the logical AND gate 374 is connected to a first input terminal of a logical AND gate 376. A second input terminal of the AND gate 376 is connected to an output terminal of a level detector 378. The level detector 378 has an input terminal connected via a conductor 380 and a resistor 382 to the output terminal of amplifier 282. Thus, the input signal to the level detector 378 is the program stop error signal developed at the output terminal of the amplifier 282. So long as the program stop error signal is negative or, if positive, so long as its magnitude is less than that of the preset negative bias in the level detector 378, this detector will provide a logical 1 signal to the logical AND gate 376 causing it to be active. If the vehicle speed is also greater than the third threshold level and the system is in the program stop mode as previously described, the AND gate 376 will produce a logical 1 output signal. An output terminal of the AND gate 376 is connected via a conductor 384 to a gate terminal of a field effect transistor 386. The output terminal of AND gate 376 is also connected to an input terminal of an inverter 388 whose output terminal is connected to a gate terminal of another field effect transistor 390. The FET's 386 and 390 work in conjunction to control an amplifier 392. The amplifier 392 is so arranged as to provide a fixed level of error signal onto the output conductor 66 when the brake anticipation circuit is active. In this regard the field effect transistor 386 has a source terminal connected through a resistor 394 to a positive voltage source. The source terminal is protected by an inverse parallel pair of diodes 396 and 398 which are connected between the source terminal and the signal ground. The drain terminal of the FET 386 is connected to a drain terminal of the FET 390. A source terminal to FET 390 is connected through a resistor 400 to a negative voltage source V-. The source terminal of FET 390 is protected by an inverse parallel connected pair of diodes 402 and 404 connected between the source terminal and signal ground.

Detailed Description Text (74):
For a better understanding of the effect of the brake anticipation circuit, reference is made to FIG. 7 in which there is shown a desired velocity versus distance profile and an actual velocity versus distance curve for a vehicle. The line 422 represents the maximum velocities of a vehicle over a range of distances from the stopping point 423 for which the vehicle can be stopped without exceeding the desired deceleration rate. The line 424 shows the actual velocity of the vehicle over a portion of the track. The point indicated at 426 is the point at which the vehicle enters into the position stop control mode. Without the brake anticipation function the velocity would remain constant until the point 428 at which the vehicle velocity intersects the desired profile. Because of the slope of this profile and the tendency of the vehicle to overshoot the performance profile as illustrated, an excessive amount of brake or jerk may be felt by the passengers. By instituting a brake anticipation function at the point 426, the vehicle can be caused to gradually slow so that the function follows the line illustrated at 430 and gradually rounds into the desired profile. This anticipation function therefore provides a smooth transition onto the desired distance/velocity profile.

CLAIMS:

1. In an automatic control system for a train of one or more wheeled vehicles traveling on a fixed guideway along which a plurality of wayside signal devices are located at different predetermined distances from a desired stopping point for providing information to the train indicative of the distance from a signal device to the desired stopping point, an improved arrangement for effecting operation of the train on a predetermined velocity-distance profile comprising:

(a) means for monitoring the rotational velocity of a selected wheel on a

predetermined one of the vehicles and for producing a first signal representative of said rotational velocity;

(b) means for producing a second signal representative of the diameter of said selected wheel;

(c) means operative each time the train passes one of the wayside signal devices for generating a third signal that indicates the distance between the train position on the guideway and the desired stopping point;

(d) addressable memory means for storing a plurality of values respectively representative of the number of revolutions that a wheel of various different diameters would turn in order for the train to move the different predetermined distances on the guideway;

(e) logic control means responsive to said second and third signals for generating a memory address that causes said memory means to output the particular value stored at that address;

(f) counter means connected for receiving said memory output, said counter means being set to the value represented by said memory output each time the train passes one of the wayside signal devices;

(g) said counter means being responsive to said first signal for counting down from said set value in proportion to the actual revolutions of said selected wheel whereby the value remaining in said counter means is a continuous reference of the distance remaining to the desired stopping point;

(h) means responsive to said first and second signals for producing a velocity signal representative of the linear velocity of the train of vehicles;

(i) means for computing a value representative of the distance remaining to the desired stopping point as a function of the linear velocity of the train and a desired deceleration rate;

(j) means for comparing said computed distance value with said reference distance value and for producing an error signal representative of the difference therebetween; and

(k) means responsive to said error signal for varying the actual velocity of the train in a manner to minimize said error signal and thereby stop said train at the desired stopping point.

2. The system of claim 1 and including means for producing a fourth signal representative of the number of vehicles in the train, said logic means being responsive to the combination of said second, third and fourth signals for generating said memory address.

3. The system as described in claims 1 or 2 wherein said error signal is summed with a signal representative of said desired deceleration rate to produce a deceleration command signal for controlling the tractive effort of the train of vehicles.

4. The system as defined in claim 3 and including:

(a) means for receiving a desired velocity command signal and for generating therefrom a velocity reference signal;

(b) summing means for combining said linear velocity signal and said velocity reference signal to thereby produce a velocity error signal; and

(c) logic means connected for receiving said velocity error signal and said deceleration command signal and for selecting the most restrictive of said signals for controlling the velocity of the train of vehicles.

6. The system of claim 3 and including means for reducing the deceleration rate of the

train by adjusting the magnitude of the desired deceleration rate signal when the linear velocity of the train is less than a first predetermined velocity and greater than a second predetermined velocity, said first and second predetermined velocities being within a low velocity range indicative of an impending stop.

7. The system of claim 1 and including brake anticipation means operative upon detection of said one wayside signal device for initiating a predetermined magnitude of braking effort of the train if said error signal is less than a predetermined value and said linear velocity signal exceeds a predetermined threshold.

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DOCUMENT-IDENTIFIER: US 6539292 B1
TITLE: Using location-influenced behavior to control model railroads

Abstract Text (1):
New methods and techniques are presented for utilizing digital information transmitted by a moving device (such as a model locomotive on a model railroad) to allow the moving device to itself influence the way it is controlled and allowing a moving device (such as model locomotive on a model railroad) to itself send specific instructions or cause others to send specific instructions to other devices on the model railroad for the purpose of controlling or influencing their behavior. These methods and techniques can be employed in the control, automation and operation of scale model railroad layouts to permit significant increases in the level of automation that can be utilized on a model railroad and with this increase the illusion of operating a real locomotive.

Brief Summary Text (3):
NMRA DCC and other similar forms of model railroad control in use today utilize a form of control referred to as open loop. The command station sends an instruction to a moving device within the locomotive and the modeler uses visual means to determine if the desired operation occurred. The Command Station has no idea if the moving device received the transmission or is even present on the layout. This is a very effective form of control as has been shown in the widespread use of NMRA DCC. However it has its limits.

Brief Summary Text (4):
Currently there is no method for a moving device to initiate the transmission of information to the control system. Without this transfer initiation it is not possible for the control system to base its decisions on what is actually occurring within the locomotive on the layout. The one exception is Service Mode. In service mode the moving device has the ability to transmit back an acknowledgement, by providing a load which the control system can identify. This is used by the control system to display to the user the contents of Configuration Variables that are stored in the moving device. An example of this is the ability to read the address of the decoder within a locomotive while on a special service mode section of track. Other techniques for detecting information are described in Zimo, Digitax and Lenz (discussed below).

Brief Summary Text (5):
Existing forms Location behavior influence. Location-influenced behavior is a technique for automating the desired operation based on the location of the locomotive or train on the layout. Having a train automatically reverse its direction at two end points is perhaps the simplest example of location-influenced behavior. Another primitive form of this technique currently in use is stopping a train in front of a red signal by transmitting a broadcast DCC stop packet to the moving device located within the block preceding the signal.

Brief Summary Text (7):
In NMRA DCC the polarity of the rails has no effect for influencing the locomotive direction. To reverse the direction of a DCC locomotive you must transmit a specific instruction telling the locomotive to reverse. This instruction is transmitted by the command station (signal generator) to the specific locomotive.

Brief Summary Text (8):

To construct an automatic locomotive reversing section in DCC one must first detect the locomotive (a primitive form of communication from the locomotive operating on the layout to a device connected to the layout) and then instruct the signal generator to reverse this locomotive. To demonstrate this concept a CAB (device used by the operator to control model trains) was modified so that direction switch is controlled by a relay that is connected to two detectors placed at either end of the reversing track section.

Brief Summary Text (9):
This primitive technique illustrates the basis for all forms of location-influenced behavior. The locomotive on the operational layout sends information to a detector. The detector transmits this information to the command station and based on this information the command stations sends new information to the locomotive to change its operation behavior or its direction of movement.

Brief Summary Text (10):
While this primitive type of DCC location-influenced behavior works, it has its limitations because the detector only gets one bit of information, that being the presence or absence of a current load on the track. If more than one locomotive is on the track section, the reversing can only work for the loco that the handheld has addressed. Without a more advanced form of two way communication it is not possible for the detection device to determine which locomotive is in the track section and therefore which locomotive it should influence behavior for.

Brief Summary Text (11):
In 1996 Zimo GmbH ("NMRA TN-9.2.1 Restricted Speed Instructions dated June 1998") presented a specification for a much more refined approach where the control system could tell the model locomotive to perform a much wider variety of operations at a specific location. This was accomplished by modifying a series of bits to tell the locomotive a specific operation to perform. Zimo calls this technique signal controlled speed influence. This technique allows a device along the layout to send specific speed or function commands which can be executed by any locomotive that passes into the region controlled by the track detector. A second form of the Zimo approach is the ability for the moving device to provide up to a 4 bit acknowledgement for specific commands sent. The approach is effective for trains with single locomotives but becomes much more complex when more than one locomotive is controlling the train. The reason for this is that the detector does not know how many locomotives are in the train and thus must have a small area for detecting the presence of the train and a larger area for influencing the behavior based upon a fixed maximum length of the train. Other disadvantages of this approach are that the locomotive can not initiate an action, all actions must be initiated by the detector and the approach affects all locomotives entering the region.

Brief Summary Text (12):
Detecting the identity (address) of a moving device can be done in one of two methods using the Zimo approach. The Zimo locomotive identification feature is for the command station to send a specific command to the moving device which the moving device will acknowledge. The acknowledgement is detected and by integrating the request with the response the knowledge that that particular moving device is somewhere in the detection zone is determined. The problems are that commands are not refreshed to a specific moving device with sufficient frequency to allow this method to effectively be combined with the behavior influence, it is not possible to determine the identity of an unknown device unless all 10,000 addresses are transmitted (requires over a minute to transmit) and the necessity to increase the preamble bits for a packet as the influenced bits may not always be read as proper bits. This slows down the transmission and is not compatible with other systems on the market that conform to the NMRA DCC Standards and Specifications. A third major problem is that the method Zimo uses to transmit the bits is a 5 amp current pulse which over time may damage the current pickups of the moving device.

Brief Summary Text (13):
Digitrax (ref U.S. Pat. No 6,220,552, issued April 2001 for a specific method for detecting a bit transmitted by the moving device) solved both the pickup damage and the preamble addition problems by transmitting the bits via a series of low current pulses which, while more difficult to detect, allow for use on any conforming NMRA DCC

system. Like the Zimo approach, this detector is able to detect the receipt of specific commands being received by a moving device as specified in NMRA RP-9.2.1 (dated August 1994). Since the commands acknowledged are address specific, the detector is able to determine the specific moving device that is in its control area. While useful for identifying locomotive location it suffers many of the same limitations that the Zimo approach does, in that the locomotive can only acknowledge a specific command sent to it and the locomotive can not initiate communication on its own. If no commands are sent to the locomotive, no acknowledgement will ever be received and an acknowledgement plus a few bits is insufficient bandwidth for a device to initiate control communication with another device. The Digitrax approach, like the Zimo approach, both suffer from the command refresh rate. The detector can not detect the presence of the moving device if a packet has not been transmitted to that moving device' address. Digitrax solves this by adding a button on the user control Cab to allow the user to initiate the location inquire packet. The invention covered by this specification solves this problem by having the moving device constantly transmits it address and train type information. Both the Zimo and Digitrax approach also have limited transmission ability and are not able to have the moving device influence it's behavior other than acknowledging the receipt of a specific command as described in the NMRS DCC specifications. The invention covered by this specification solves these problems by utilizing the entire transmission packet for transmission back and be defining self clocking zones for the different types of information being transmitted.

Brief Summary Text (16):
All these existing forms of communication are based on the premise that you can only influence the behavior of a model locomotive (example of a moving device) in a specific location and then only get back an acknowledgement that the action was successful. None of the proceeding technologies allowed the locomotive to initiate activity.

Drawing Description Text (12):
FIG. 11 illustrates the solution to the problem illustrated in FIG. 10 by providing a safe zone that occurs after the rear wheels of the front locomotive have completely entered the detection zone and before the front wheels of the second moving device have entered the detection zone.

Detailed Description Text (13):
Using the proposed framework for bi-directional communication a detector can detect the actual address of the moving device within the detection zone and from this request specific commands be sent to that particular moving device to do such things as restrict the speed of the train in front of a yellow signal or through an interlocking, stop the train at a station or in front of a red signal, or blow the whistle in front of a grade crossing.

Detailed Description Text (14):
Other uses of Location-influenced behavior include allowing the user to place a moving device on the track and instantly being told of the moving device' address. Such a technique is also useful in hidden yards for identifying specific trains. This invention also includes a technique for the moving device to tell the system which route to take and for the moving device to also tell the system what type of train it is, for the purpose of influencing the behavior modification (high speed passenger trains have different rules at signals than slow freights.) These techniques are described in subsequent paragraphs.

Detailed Description Text (15):
In the following paragraphs specific examples are provided to back up the claims made in this application. FIG. 5 provides a method for a moving device to influence the behavior of an external device. In this method the moving device transmits its identity for the purpose of sounding specific sounds as it approaches a grade crossing. The locomotive moving device sends a broadcast command which is read by a detector along side the layout. Based on the train type information received the detector selects the correct sound type and transmits it to an under table sound device. The result is that the moving device has influenced the behavior of the under table sound device

Detailed Description Text (21):
FIG. 7 illustrates how the data transmission method for a moving device on the model railroad can be used by the moving device to influence the way a user controls its behavior. This is provided to allow the model railroad operator to have the illusion of the experience of actually operating a prototype locomotive.

Detailed Description Text (31):
If you have only a single locomotive in a block with a detector, detection is simple as you only have a single transmitter. However, when a locomotive bridges the block boundary it may provide the electrical path for the transmission of all the other broadcast data for other locomotives on the layout.. The worst case situation is two moving devices in a consist traveling at a high speed. Using FIG. 10 as an example, if we consider HO for a moment there is slightly more than an inch between the last wheel of the first moving device and the first wheel of the second moving device for the detector to be able to have only a single moving device transmitting in its detection zone. When the first moving device enters the detection zone the moving device itself forms an electrical path allowing the broadcast information of the second moving device to also enter the detection zone. When all the wheels of the first moving device enter the detection zone and before the first wheel of the second moving device enter the detection zone, only a single device is transmitting and the data received is valid. FIG. 11 illustrates this data valid zone. Now consider that the moving devices are traveling at a speed of 100 scale miles an hour. In HO scale for example, a moving device will travel over 20 inches in a second which provides less than 0.05 seconds for the detector to properly detect a transmitter or about 9 DCC packet times. This provides the design constraint, which this invention must satisfy.

Detailed Description Text (41):
To satisfy the time constraints imposed with a moving device moving at maximum speed, and still ensuring that more than two complete transmissions can always be received, the following is provided as an illustration on how two to three packets can be used to transmit the moving device's complete address along with four data flags. Additional preambles are used to transmit additional information such as train type and route information.

Detailed Description Text (44):
The CDDD and DDDD nibbles are encoded and transmitted in 6 preamble bits each providing 13 bits needed for transmission (2*6+1). The encoding scheme calls for three 0 bits and three 1 bits to always be transmitted for each nibble. If you receive 4 then you have an error caused by multiple locomotives transmitting. This allows 7 databits to be sent during each preamble. Some datagrams contain more data than can be contained in a single datagram. In this case C is used to distinguish between the first part and the second part. C=0 1st part of transmission, C=1 second part of transmission

Detailed Description Text (54):
The following additional datagrams may be transmitted along with the moving devices address: Train type 1 or 20 options) and or Route Control. Route control allows the moving device to select one of 20 routes that the moving device should be switched to move on.

Detailed Description Text (56):
[Additional datagrams for train type identification and desired route identification]

Detailed Description Text (57):
Train Type is used to tell the detector the type of train that is entering the detection zone. This is for the purpose of deciding how to control it and also controlling external devices.

Detailed Description Text (59):
[Example Train Type Table]

Detailed Description Paragraph Table (1):
1: The moving device broadcasts its address and train type. 2 A detector listening to information being transmitted, detected the arrival of the train in its detection zone. Based on the train type the detector causes the transmission of the desired

sound to a speaker located under the layout. For example a steam whistle for a steam train and a diesel whistle for a diesel as the train approaches a grade crossing.

Detailed Description Paragraph Table (2):
1 The moving device broadcasts its address and train type. 2 A detector listening to information being transmitted hears the arrival of the train in its detection zone and transmits the desired information to the signal generator, which tells the specific sound generator to respond to sound commands sent to this moving device' address. 3 Alternately, the signal generator addresses the nearest sound generator and assigns this sound generator to listen to specific instructions for the specific locomotive in its area. 4 The sound generator begins transmitting background sounds unique to the train type being controlled and the speed of the locomotive. 5 A user changes the speed of the locomotive and desires to blow the horn. 6 The signal generator transmits the specific commands to the locomotive address 7 This information is amplified and transmitted to the track 8 The locomotive changes the speed and if applicable performs the desired function 9 The sound generator being assigned to the same address hears the same commands and changes the background sounds to reflect the new speed and the other user initiated sound functions are also activated. As the train moves on the layout, the assignment of the signal generator generating the sound moves with the train providing the illusion that the sound is coming from the moving device on the layout.

Detailed Description Paragraph Table (3):
1 The moving device on the model railroad is constantly transmitting its address and train type information. 2 A detector connected to the track detects the presence of the moving device and notifies the digital control signal generator that this particular moving device has entered its detection zone. 3 The digital control signal generator transmits a refresh speed and direction packet to the moving device. 4 A power station adds current to the instruction and transmits it to the moving device on the layout. 5 The moving device determines that the instruction is for itself by comparing its address to the address in the instruction and performs the desired operation. In the packet that immediately follows the instruction the moving device transmits the back emf load information that represents the current draw of the motor and in turn the load of the entire train. 6 A detector connected to the track listens both to the transmission of packets to the railroad and to response coming back from the layout. The detector performs the data aggregation to associate the data being received with the address transmitted in the previous packet and transmits the load received to the cab device that is controlling the train 7 The cab now knowing the load of the train being controlled can modify the look and feel of the user interface. For example, a lightly loaded train will respond quickly to a minor variation of power or breaking applied. A fully loaded train has more momentum and responds much slower. Adjustments can also be made by the cab as a result of changes of load received due perhaps to the train climbing a grade. New information for control is transmitted to the digital control signal generator. 8 The digital control signal generator constructs new instructions based on the user input from the cab and transmits this new information to the power station. 9 A power station adds power to the signal and transmits it to the moving device on the layout. 10 The command station can make this information available to a controlling device (handheld) which can vary the braking rate and acceleration rate based on the load derived from the back emf energy. This information can also be made available to an under table sound system for the purpose of varying the volume and chuff rate sounds of the locomotive. This revised information can then be used to subsequent commands to the moving device on the model railroad (locomotive).

Detailed Description Paragraph Table (4):
1 A signal located on the model railroad is instructed to turn red. 2 The moving device on the model railroad is constantly transmitting its address and train type information and enters the area being influenced by the signal. 3 A detector connected to the track detects the presence of the moving device and knowing that the signal is red instructs the digital control signal generator to stop the train. 4 The digital control signal generator knowing the speed of the train and the train type transmits a series of slow down instructions followed by a stop instructions to the specific moving device. 5 A power station adds current to the instruction and transmits it to the moving device on the layout. 6 The moving device determines that the instruction is for itself by comparing its address to the address in the instruction slows down

and stops the train. In the packet that immediately follows each change of speed and stop packet instruction the moving device transmits a positive acknowledgement. 7 A detector connected to the track listens both to the transmission of packets to the railroad and to response coming back from the layout. The detector performs the data aggregation of the acknowledgement with the address transmitted in the previous packet and transmits the acknowledgement back to the digital control signal generator. 8 Once the train is stopped, the digital control signal generator having received a positive acknowledgement can stop sending refresh packets to the moving device until the signal turns green and the moving device can proceed.

Detailed Description Paragraph Table (5):
1 A moving device on the railroad has a detector that can read data tag transponders located along the layout 2 The moving device on the model railroad is constantly transmitting its address and train type information and an indication that it has data to transmit. 3 A detector connected to the track detects the presence of the moving device and notifies the digital control signal generator. 4 The digital control signal generator transmits a data inquiry packet to the moving device. 5 A power station adds current to the instruction and transmits it to the moving device on the layout. 6 The moving device determines that the instruction is for itself by comparing its address to the address in the instruction and performs the desired operation. In the packet that immediately follows the instruction the moving device transmits the identify of the last data tag transponder it passed over. 7 A detector connected to the track listens both to the transmission of packets to the railroad and to response coming back from the layout. The detector performs the data aggregation of the moving device Data Transmission with the address transmitted in the previous packet and transmits the moving device's address and data to the cab controlling the locomotive. 8 The cab can now display the location of the moving device on the layout. 9 The digital control signal generator can calculate when it can expect the moving device to pass the next data tag and ensure that a refresh packet is sent near the time the tag is passed. 10 A power station adds current to the instruction and transmits it to the moving device on the layout. 11 The moving device can transmit a new tag location once it detects the tag and in this way continuously transmit its location to the cab that is controlling it.

Detailed Description Paragraph Table (10):
Flag Meaning of flag when set to have a value of "0" F1 Do not influence behavior for this locomotive address. F2 I have data to send F3 I am operating at a consist address F4 Direction of movement is reverse to normal

Detailed Description Paragraph Table (11):
Message Type CDDD DDDD Route Control Special 2 1 of 20 routes Train Type Special 1 1 of 20 train types

Detailed Description Paragraph Table (12):
Transmitted Bits Train Type Locomotive Train Type 111000 Steam Local Switcher 110100 Steam Way Freight 110010 Steam Fast Freight 110001 Steam Local 101100 Steam Express 101010 Diesel Local Switcher 101001 Diesel Way Freight 100110 Diesel Fast Freight 100101 Diesel Local 100011 Diesel Express 011100 Electric Local Switcher 011010 Electric Way Freight 011001 Electric Fast Freight 010110 Electric Local 010101 Electric Express 010011 Reserved Reserved 001110 Reserved Reserved 001101 Reserved Reserved 001011 Reserved Reserved 000111 High Speed Express High Speed Express

Other Reference Publication (1):
"Renewed Proposal for Signal Controlled Speed Influence and Train Number Identification for NMRA-DCC protocol", ZIMO Elektronik, Oct. 13, 1996.

L21: Entry 9 of 18 File: USPT Nov 25, 1980

DOCUMENT-IDENTIFIER: US 4235402 A
TITLE: Train vehicle speed control apparatus

Abstract Text (1):
The present invention relates to a train vehicle speed control apparatus which recognizes a change in one of the acceleration rate or the deceleration rate of a train moving along the track and the control of the train velocity in relation to what distance will be required for a desired operation of the train such as a predetermined decrease in the train speed or a stopping of the train. If the deceleration rate has changed, for example, the fixed physical system limits what control can be exercised and the velocity of the train can be modified to adjust the actual stopping distance used by the train or with a fixed stopping distance desired then the permitted train velocity can be changed.

Brief Summary Text (2):
It is known to control the movement speed of one or more train vehicles moving along a track including a plurality of signal blocks through the use of speed code signals in accordance with desired fail-safe control system operation. Prior art discloses of similar railway track signaling systems can be found in U.S. Pat. No. 3,562,712 of G. M. Thorne-Booth et al, U.S. Pat. No. 3,551,889 of C. S. Miller and U.S. Pat. Nos. 3,532,877 and reissued 27,472 of G. M. Thorne-Booth. In addition, an article entitled "Design Techniques For Automatic Train Control" by R. C. Hoyler in the Westinghouse Engineer for July, 1972 at pages 98 to 104 and an article entitled "Automatic Train Control Concepts Are Implemented By Modern Equipment" by R. C. Hoyler in the Westinghouse Engineer for September, 1972 at pages 145 to 151 describes train control equipment design for safe operation.

Brief Summary Text (3):
For the purpose of starting and stopping the movement of a train, it is desired to know the value of the adhesion coefficient of friction between the train wheels and the track rail upon which the train is moving. The operational speed permitted for a second train following an earlier first train is determined in part by the location of the first train on the track ahead of the second train as well as the adhesion condition of the track ahead of the second train. If it is desired to stop the second train a predetermined safe distance behind the first train with no concern about a collision between the two trains, it is necessary to determine a safe distance to begin stopping the second train behind the first train. This distance is a function of the adhesion level and the resulting deceleration rate that can be reasonably achieved by braking the train in relation to the train velocity. In general this stopping distance D can be determined by the relationship:

Brief Summary Text (4):
where V is the train velocity and R is the known deceleration rate. If rain, ice or some other film material is present on the track, this will change the deceleration rate R.

Brief Summary Text (5):
It is known to provide wheel slip or slide detection and control apparatus to remove a command for propulsion or braking of the train until the abnormal adhesion situation is corrected. The tractive or braking effort being applied to the wheel axle must be corrected to permit the wheels to regain the speed equivalent of the train speed. A speed signal is developed for each axle by suitable speed sensors with a D.C. output

voltage proportional to frequency of the output of the speed sensor being developed and a derivative of this voltage being used to trigger a slip slide control system, as described in a publication entitled "Propulsion Control For Passenger Trains Provides High Speed Service" by J. E. Moxie et al in the Westinghouse Engineer for September, 1970, at pages 143 to 149. When the derivative voltage exceeds a value equivalent to wheel acceleration or deceleration of 8 miles per hour per second, an output from the slip slide control system picks up a relay to initiate action that reduces the tractive or braking effort until the slip or slide is eliminated. Once the slipping or sliding condition has been eliminated the wheels should return to a speed equivalent to train speed. An assumption can be made that the return to speed will be in the order of the rate of 8 miles per hour per second or greater, therefore a speed derivative with a sign opposite the sign of the derivative signal that initiated the reduction in tractive or braking effort can be used to reset the control system, eliminate the system output, drop out the control relay and reestablish the desired braking or tractive effort. It is recognized that the assumption that an equivalent wheel deceleration always follows a wheel slip acceleration and vice versa may not be valid and for this reason a time out circuit is provided with timing initiated when a system output signal occurs. If the opposite sign derivative does not occur before the end of three seconds, the control system is reset and the relay dropped out by the timing circuit which relay drop out then permits the desired tractive or braking effort to be reestablished.

Brief Summary Text (7):
The slip slide control signal operates with the speed command control equipment carried by the train to lower the vehicle operating speed down to a safe minimum adhesion level, which has been previously determined and permits stopping the train in the provided distance. The vehicle either stops in accordance with a normal level of operation or in accordance with a predetermined minimum level of operation. If desired an adaptive control system can be provided knowing the train characteristics and the extend and kind of the slip slide track condition that has actually occurred. A time duration can be sensed for a given slip slide condition or several short time slip slide conditions are integrated to slow down the train speed. By using a control signal determined by the activity of the vehicle wheels it can be determined if only a short slip slide condition occurrence is presented or an extended slip slide activity condition is presented.

Brief Summary Text (8):
The present speed control apparatus can be onboard carried by each vehicle so each train determines its own response. The first train in the morning, for example, moves into an environment including fog and rain with some rust film on the rails and may experience a considerable amount of slip slide activity and have to operate at some reduced level. However, the tenth or may be the twentieth train that passes over the same rails the same day will probably be able to operate at the normal speed level.

Drawing Description Text (2):
FIG. 1 is a schematic showing of the present train vehicle speed control apparatus;

Drawing Description Text (6):
FIG. 5 illustrates a first wayside operative train vehicle adhesion characteristic determination apparatus; and

Drawing Description Text (7):
FIG. 6 illustrates a second wayside operative train vehicle adhesion characteristic determination apparatus.

Detailed Description Text (2):
Rapid transit systems generally achieve large flow capacity of maximizing the performance of the train vehicle within the constraints of the system safety. As a rule headways and/or close up distances are based upon the speed and braking rate, for example, if a speed V is being maintained for the train vehicle and a braking rate R is available then the distance D is required to stop the vehicle as set forth by above equation (1). If the available braking rate R is reduced, then either the distance D must be increased or the velocity V reduced to achieve their required safety margin. This present invention can be utilized to allow the maximum use of available deceleration capability of the train vehicle in relation to the track in order to

preserve system safety. It was known in the prior art to determine the system safety criteria assuming either an average value of the coefficient of friction for all parts of the system under all conditions or a minimum value existed as a worse case for all calculations. Assuming that the first condition is made it is easily understood that under an adverse condition it might be feasible to cause an accident because of a lesser than average required deceleration rate being available, and assuming the second case it is again easily seen that if all margins are calculated on a worse case basis, significant deterioration of system capability results. The present invention is adaptable to automatic or manual control systems for achieving maximum useful capacity consistent with the available deceleration or ~~acceleration rate and is~~ particularly useful in automatic ~~systems that are used in~~ regions where sudden climatic changes cause significant change in traction capability.

Detailed Description Text (3):
As shown in FIG. 1 a propulsion and braking control apparatus 10 carried by a train vehicle 11 in relation to movement along a track 13 is operative with one or more propulsion motors 12 and the vehicle brake system 14. One or more tachometer speed sensors 16 coupled to the vehicle wheels provide an actual speed feedback signal over conductor 18 to the vehicle speed regulation apparatus 20. A desired speed signal is supplied over conductor 22 to the speed regulation apparatus 20 from a speed signal receiver 24 operative with an antenna 26 carried by the vehicle 11 and a speed command decoder 28. The speed regulation apparatus 20 provides a P signal as described in an article entitled "Automatic Train Control Concepts Are Implemented By Modern Equipment" by R. C. Hoyler and published at pages 145 to 151 in the September, 1972 Westinghouse Engineer and in the above-mentioned article entitled "Propulsion Control For Passenger Trains Provides High Speed Service" by J. E. Moxie et al. The P signal on conductor 30 goes to the propulsion and braking control apparatus 10. Separate speed sensors 15 coupled to the vehicle wheels supply a speed signal to the slip slide monitoring apparatus 32 which provides a slip slide control signal on conductor 34 to the propulsion and braking control apparatus 10 and on conductor 60 to a track adhesion condition sensing apparatus 36 in relation to the time and the extent of each wheel slip or slide condition of the wheels of vehicle 11 in relation to the track 13. The track adhesion condition sensing apparatus 36 provides a control signal on conductor 38 to the speed regulation apparatus 20 such that there results a modification of the desired speed command signal for modifying the speed error signal on conductor 30 going to the propulsion and braking control apparatus 10.

Detailed Description Text (4):
The speed regulation apparatus 20 is operative with the speed signal receiver 24 and the speed command decoder 28 such that a plurality of input frequency signals are available over the conductor 22 indicating at what desired speed the vehicle 11 should be running and this supplies a respective crystal oscillator within the speed regulation apparatus 20 to determine the vehicle speed by providing a desired speed signal.

Detailed Description Text (5):
In FIG. 2 the speed regulation apparatus 20 including the provided input crystal oscillators are shown, with the frequency of the desired speed signal being fed from input crystal oscillator 50 into a digital monostable 52, such as disclosed in U.S. Pat. No. 3,749,994 of T. C. Matty, for converting the frequency signal from the crystal oscillator 50 into a precise analog desired speed signal voltage which is supplied to the comparator 58. The speed sensors 16 operative with the wheels of the train vehicle 11 provide an actual speed signal to the comparator 58 for comparison with the desired speed signal from the digital monostable 52 such that a speed error signal is provided by the comparator 58 over the conductor 22 to the propulsion and braking control apparatus 10. In addition the actual speed signal from the speed sensor 15 is supplied to a slip slide monitoring apparatus 32 which provides an output signal over the conductor 60 when there is an excessive slip condition sensed or there is an excessive slide condition sensed between the wheels of the train vehicle 11 and the track 13. When the control signal on the conductor 60 is provided, a crystal oscillator 62 having a predetermined frequency of operation is energized to supply a signal through the OR gate 56 to the digital monostable 52. The crystal oscillator 62 operates at a higher frequency as compared to the crystal oscillator 61 to in effect reduce the magnitude of the analog output voltage supplied by the digital monostable 52 and this operates to lower the speed of the train vehicle 11. As well known to

persons skilled in this art, the digital monostable 52 can provide an output average D.C. voltage which is a function of the pulse rate determined by the input frequency signal from oscillator 50 and a function of the pulse period determined by the frequency of the input frequency signal from one of oscillators 61 and 62. Since the frequency of oscillator 62 is higher than the frequency of oscillator 61, the pulse period is less for the former oscillator 62 and the output voltage from the digital monostable will be correspondingly less. By proper selection of the respective frequency of the crystal oscillator 62 as compared to the frequency of the crystal oscillator 61, any percentage of speed reduction for the train vehicle 11 can be provided as desired in relation to the slip condition or the slide condition sensed between the wheels of the train vehicle 11 and the track 13.

Detailed Description Text (6):
In FIG. 3 there is functionally illustrated the operation of the slip slide monitoring apparatus 32 such that the actual speed signal from the speed sensors 16 is supplied over conductor 17 to a one shot circuit 70. The frequency of the pulse input signal supplied on conductor 17 is proportional to speed and the signal when applied to the one shot 70 gives a calibrated output pulse signal and a repetition rate the same as the rate of the input signal on conductor 17. The output signal from the one shot then passes through a low pass filter 72 and since a known volt time area is involved at a given rate the average voltage is proportional to the vehicle speed. A differentiator circuit 74 can be used to sense slip slide conditions and the output of the latter is proportional to the rate of change of the average voltage. A level detector such as a schmidt trigger is provided to sense the positive rate of change in excess of normal and a second level detector 78 is provided to sense the negative rate of change in excess of normal. The OR gate 79 will output a control signal on the conductor 60 if an abnormal slip condition or an abnormal slide condition is sensed between the wheels of the train vehicle 11 in the track 13. For a normal condition no output signal will be provided by the OR gate 79. The resistor 73 and capacitor 75 will sense an out of bounds from normal rate of change of the signal from the one shot 70. The typical acceleration and deceleration for a mass transit system can be in the order of 3 miles per hour per second. The level detectors 76 and 78 are set to detect in the order of an 8 mile per hour per second rate of change of velocity whereas the normal rate of change will be under 3 miles per hour per second. An abnormal slip condition would be faster and have a higher slope to the velocity curve. Once the slip slide monitoring apparatus senses an abnormal condition, an output control signal is provided by the OR gate 79 to the conductor 60 which then becomes operative with the track adhesion monitoring apparatus 36.

Detailed Description Text (7):
In the same way vehicle deceleration monitoring may be used to determine what braking effort is achieved when a maximum rate is requested and if the response is not within allowed specifications then corrective action can be instituted such as lowering the speeds on a speed limit or percentage basis. Similarly, vehicle acceleration monitoring can be provided to allow sensing of poor adhesion level prior to the vehicle reaching a possible unsafe high speed from which is could not safely stop.

Detailed Description Text (10):
The capacitor 89, resistor 90, transistor 91 operate as a minimum pulse circuit to assure that once the relay 88 is deenergized then the contacts 87 will stay open for a small time duration for the benefit of the speed regulation apparatus 20 to respond adequately to the opening of the contacts 87. When the contacts 87 open, the conductor 92 will no longer provide voltage to energize the relay 93 and this opens by gravity the latching contact 94. In addition the contact 95 now opens to discontinue the operation of oscillator 61, and the contact 96 closes to initiate the operation of the oscillator 62. A momentary manual reset switch 99 is provided to energize the relay 93 and close the contacts 94 and 95 when desired by the train vehicle operator.

Detailed Description Text (16):
In FIG. 5 there is illustrated the wayside measurement of vehicle performance in relation to a provided speed change signal or an automatic speed change which occurs at a known location along the track. If the train vehicle 11 is running at its normal speed as it passes a predetermined slow down point along the track 13, either the time to reach a fixed distance or the speed of the vehicle at a fixed distance can be measured. In FIG. 5 there is illustrated apparatus for measuring the speed of the

vehicle 11 at a fixed distance. The speed signal transmitter 120 operative with antenna 122 in relation to a shunt 124 connected between the rails 126 and 128 of the track 13 is operative to provide a change in the speed command to the vehicle 11 when it enters the track signal block terminated at one end by the shunt 124. When the vehicle reaches the location of vehicle detector 100 a known distance away from the antenna 122 the wayside detection apparatus 102 can establish the time duration of the passage of the vehicle between the location of the vehicle detector 100 and a second vehicle detector 104 having a known spacing or distance between the vehicle detector 100 and the vehicle detector 104. In this way the speed of the vehicle 11 passing between the vehicle detector 100 and the second vehicle detector 104 can be established. Knowing the speed of the vehicle 11 passing between the vehicle detector 100 and vehicle detector 104 permits an evaluation of the available adhesion level of the wheels of the trains vehicle 11 in relation to the track 13 and this permits appropriate wayside vehicle speed control action to be initiated. For example, if the adhesion is poor in this respect the speed command to the train vehicle can be lowered by suitable speed command in subsequent track circuit signal blocks or the safe distance permitted between successive train vehicles could be increased through changes in the provided safe stopping profile.

Detailed Description Text (17):
In FIG. 6 there is shown a wayside detection of vehicle performance in relation to illustrated track circuit signal blocks N-2, N-1, N, N+1, N+2 and N+3 as determined by shunt connectors between the rails of the track 13. A speed encoder 110 operative with the track circuit signal block N=2 is operative to provide a predetermined vehicle desired speed level within the signal block N-2. The wayside detection apparatus 112 is operative with the transmitter 114 to provide a different speed of operation in relation to the signal block N-1 and the receiver 116 is operative with the wayside detection apparatus 112 to determine when the train vehicle 11 enters the signal block N+2. Since the physical distance between the signal block N-1 and the signal block N+2 is known, this permits the wayside detection apparatus to determine the vehicle acceleration or deceleration between the change of speed command provided by the transmitter 114 in relation to track circuit signal block N-1 and the time required for the vehicle to reach the signal block N+2.

Detailed Description Text (18):
The vehicle measurement illustrated by FIGS. 5 and 6 are vehicle passive and can be implemented on a zone region basis and could control the vehicles passing through the particular zones involved. The control apparatus illustrated in FIG. 1 is carried by the train vehicle.

Detailed Description Text (19):
In addition to the control apparatus as shown in FIG. 1, it is feasible to send a signal from the vehicle whenever a poor adhesion condition is established which transmission could take place at identified locations or it could be sent through a radio link such that a system or a subsystem speed restriction could then be enforced as considered to be necessary. In the operation of the control apparatus as shown in FIGS. 1 and 2, the speed control provided by the crystal oscillator 62 could for example provide a running speed of 75% of the otherwise desired speed provided by the desired speed signal from the speed command decoder 28 if desired.

CLAIMS:

1. In train vehicle speed control apparatus for determining the operation of a train vehicle having at least one wheel operative with a track, the combination of:

means for sensing the actual rate of change of the speed of said wheel;

adhesion condition sensing means operative with said actual rate of change sensing means for determining when said actual rate of change is greater than a predetermined rate of change;

means operative with said adhesion condition sensing means for providing a first speed control signal when said actual rate of change is not greater than said predetermined rate of change;

means operative with said adhesion condition sensing means for providing a second speed control signal when said actual rate of change is greater than said predetermined rate of change, and

means for controlling the speed of said train vehicle in response to one of said first speed control signal and said second speed control signal, with the first speed control signal having a frequency different than the second speed control signal, and with said speed controlling means being responsive to the pulse period of the first and second speed control signals.